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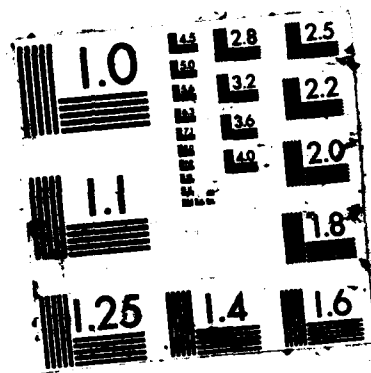   .. S A KASSAM 20 DEC 86 AFOSR-TR-87-1455
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ANNUAL TECHNICAL REPORT OF RESEARCH

ON

STATISTICAL TECHNIQUES FOR SIGNAL PROCESSING

Saleem A. Kassam

Principal Investigator

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REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY N/A	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for Public Release; Distribution Unlimited
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S) AFOSR·TR· 87-1455

6a. NAME OF PERFORMING ORGANIZATION University of Pennsylvania	6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION AFOSR/NM
6c. ADDRESS (City, State and ZIP Code) Department of Electrical Engineering 200 South 33rd Street Philadelphia, PA 19104-6390		7b. ADDRESS (City, State and ZIP Code) Bldg. 410 Bolling AFB, DC 20332-6448
8a. NAME OF FUNDING/SPONSORING ORGANIZATION AFOSR	8b. OFFICE SYMBOL (If applicable) NM	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER AFOSR Grant 82-0022

8c. ADDRESS (City, State and ZIP Code) Bldg. 410 Bolling AFB, DC	10. SOURCE OF FUNDING NOS.			
	PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT NO.
11. TITLE (Include Security Classification) Annual Technical Report of Research on "Statistical Techniques for Signal Processing	6.1102F	2304	A5	

12. PERSONAL AUTHOR(S)
Saleem A. Kassam

13a. TYPE OF REPORT Annual/Interim	13b. TIME COVERED FROM 11/1/85 TO 10/31/86	14. DATE OF REPORT (Yr., Mo., Day) Dec. 20, 1986	15. PAGE COUNT 6

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB. GR.	Nonlinear Filters, Robust Estimates, Rank Estimates, Nonparametric Detection, Conditional Tests, Quantization, Non-Gaussian Noise
	XXXXXXXXXXXXXX		

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This report summarizes research accomplishments in the 12 month period Nov. 1, 1985 – Oct. 31, 1986. Significant advances have been made in nonlinear filtering based on robust estimation, on nonparametric detection, and on a new noise model for signal-dependent and multiplicative noise. Reference is made to 11 publications.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS ☐	21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED	
22a. NAME OF RESPONSIBLE INDIVIDUAL Major Brian Woodruff	22b. TELEPHONE NUMBER (Include Area Code) 202/767-5027	22c. OFFICE SYMBOL AFOSR/NM

DD FORM 1473, 83 APR EDITION OF 1 JAN 73 IS OBSOLETE.

SUMMARY OF PROGRESS IN PREVIOUS YEAR (STARTING NOVEMBER 1, 1985) OF RESEARCH UNDER GRANT AFOSR 82-0022

The grant year covered by this report began on November 1, 1985; it was the fifth year of continuing effort on the development of new "Statistical Techniques for Signal Processing". The progress made in the first four years of this effort has been documented in four previous annual reports (December 1982, 1983, 1984 and 1985). In addition, advances made over a five year period under a previous grant period (AFOSR 77-3154) have been described in five earlier annual reports.

Here we summarize our activity in this latest complete year of research effort. Some interesting and significant results have been obtained and reported during this period; these are listed as references [1]-[11]. Copies of references currently available will be forwarded shortly under separate cover.

The area of nonlinear edge-preserving robust smoothing continued to be an area of primary focus of our research. In [1] preliminary results have been given of our work on edge-preserving, impulsive-noise rejecting, frequency selective filters using combined temporal/rank-order data matrices. We have obtained very good success in combining frequency selectivity, which requires linear temporal filtering, with the nonlinear order-based treatment of time series for outlier rejection and edge-preservation. We have been working on extending this study and are preparing a journal paper on this subject. We have also obtained very encouraging results on R-estimates of statistical theory in nonlinear filtering applications for edge-preserving smoothing of noisy signals. Specific results on modifications of the Wilcoxon rank

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statistic leading to filters using temporally close observation pairs in forming the set of Walsh averages and M-wise instead of pairwise averaged quantities are contained in [2,3]. These Limited degree Extended averaging Wilcoxon (LEW) filters possess some very good characteristics. These results in extended form are also shortly to be submitted for journal publication.

In other work related to nonlinear filtering we have obtained results on the application of trimmed mean and related order statistic techniques in radar constant false alarm rate (CFAR) detection processing [4]; these results are currently being prepared for journal publication. Paper [5] was revised this year, and contains a treatment of the statistical characteristics of some L- and M-filters in edge preservation and noise rejection. We have considered specifically the performance of the alpha-trimmed mean and the standard-type M-filter in noise suppression at signal edges. These results extend earlier results on median filtering.

The invited paper [6] was also prepared last year. It contains our new results on the use of conditional statistical tests in obtaining counterparts of the very simple and useful sign detector, for nonparametric detection of narrowband deterministic and random signals. This work is an example of how useful and elegant new statistical procedures can be obtained for signal processing problems which do not directly fit the standard formulations in statistical theory, by a proper interpretation of the problem and extension of available theory.

We have also in the past year formulated and applied in signal detection studies a new model for noisy observations. This model extends the common additive signal and noise assumption to one admitting signal-dependent and multiplicative noise terms as well. Such a model may be much more realistic in many practical situations. In [7,8] we have given preliminary results on locally most powerful detector structures

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for the known signal detection problem in this generalized observation model. The results form a generalization of the common results on detection in additive noise. We have also made asymptotic and finite-sample-size performance comparisions with other common detectors, and have demonstrated that sizeable performance gains may be realized by using this model if it is indeed applicable, rather than the usual additive noise model. We have recently submitted a paper for journal publication on this subject, and are working on extending the results to the random signal case.

In one secondary area of our research we have published an interesting result [9] on coding of binary images. Our method exploits the two-dimensional statistical redundancy in such images but requires only the use of a one-dimensional coding algorithm applied separately in each of the two dimensions.

A book chapter was also published during this grant period on the subject of data quantization in signal detection [10].

In addition to the above we have put in efforts in revising previously submitted papers on robust detection, quantization, and statistical characterizations of nonlinear filters. The principal investigator is also completing a monograph/text on detection of signals in non-Gaussian noise [11]. Finally, we note that the Ph.D. dissertation research of a graduate student was almost completed during this year.

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PERSONNEL SUPPORTED

I. H. Song, Graduate Research   12 Months
Assistant

S. A. Kassam, Principal   3.35 Months (15% Academic
Investigator   Year, 2 Months Summer)

Beyond the one graduate student supported by AFOSR, the principal investigator was also supervising one thesis student and two Ph.D. dissertation students who are working on areas of research directly related to this AFOSR reseach program.

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